JOY (C. A.)

The art of Ventilation.

THE ART OF VENTILATION.

By Professor Charles A. Joy, Ph. D.

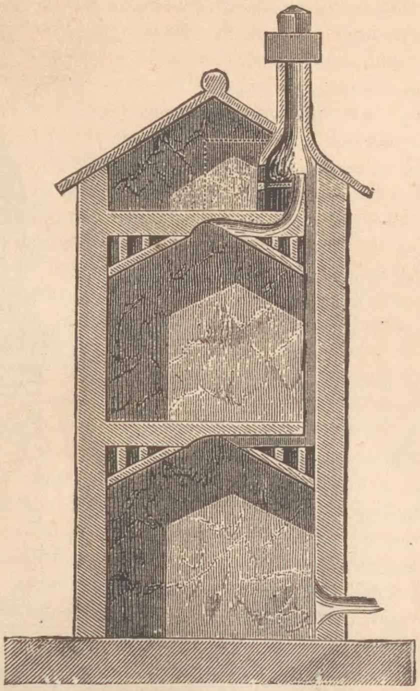
There is no topic on which so much has been written and so little is known as the art of ventilation. There are as many views on this question as there are directions in which the weather-vane can point, and it would almost seem to be a hopeless task to endeavor to bring order out of such a chaos of opinions.

It is not to be wondered at, therefore, that a skepticism proportional to the confusion of ideas prevails in the popular mind, and that a majority of mankind endure in silence what they think they cannot remedy.

We live at the bottom of a great ocean of fluid, which, under ordinary circumstances, is a gas, but by great pressure and intense cold is capable of being converted into a solid like the granite of the mountains. As a rule, we do not see the atmosphere, neither do we hear it nor feel it. We move in it as a fish does in water, and die sooner when deprived of it than does the fish when it is cast upon dry land.

The first act in the drama of life is to draw a breath, and the last is to cease from respiration. The immortal chemist Lavoisier showed that he understood the true principles upon which life is dependent, when he traced, more than one hundred years ago, the analogy between respiration and combustion: "Respiration is the gentle combustion of carbon and hydrogen, analogous to that which takes place in a burning lamp. In respiration as in combustion, it is the atmospheric air which furnishes the oxygen and heat; but in respiration it is the very substance of the animal, the blood, which supports the combustion. If animals do not constantly repair by food the loss incurred by respiration, the fuel will soon be wanting in the body, and the animal will perish, as the lamp goes out when its oil is exhausted." This analogy between respiration and combustion, did not escape the poets and philosophers of antiquity. The fire snatched from heaven, "The torch of Prometheus," does not simply present an ingenious poetical idea, it is the faithful picture of the operations of nature. The torch of life is ignited the moment the child is born, and it is not extinguished until death."

M. D'ARCET.



GENNETTI'S VENTILATING APPARATUS.

Lavoisier early appreciated the necessity of oxygen to respiration, and hence that gas was at first called "vital air." This vital air it is which we see introduced into every place occupied by man, and the way to do this must be ascertained by studying the laws of ventilation. Hence the subject is one of the first importance, and we can well afford to devote some time to its consideration.

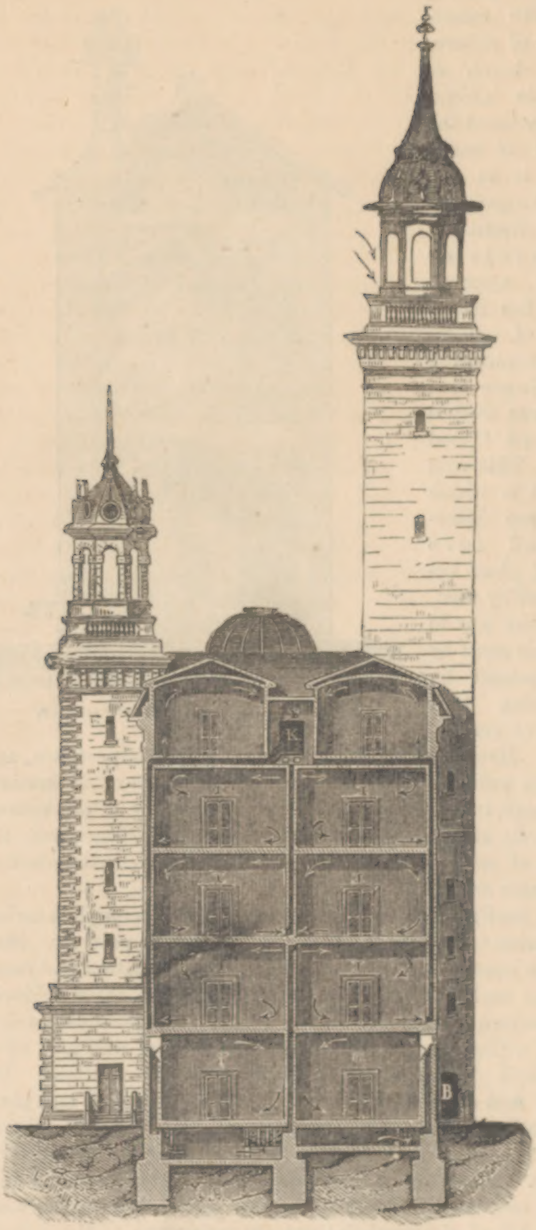
I have, in a former article, given a history of the various methods resorted to for warming our dwellings, and the topic of ventilation can well be treated as a continuation of the same subject.

No heating of a room can be said to be complete unless provision is also made for supplying it with pure air. Simply to heat the bad air is to bring on suffocation and cause death; and unfortunately this result is too often achieved by modern inventions. When a number of persons are shut up in a closed space they soon begin to feel dull and ill at ease, and do not revive until fresh air is admitted. We know that a person in respiring takes up oxygen and gives out carbonic acid. The quantity of carbonic acid exhaled from the lungs of an adult is 250 gallons every twenty-four hours. There are in the same time four pounds of moisture given out, contaminated by minute particles of organic matter. All of these exhalations are poisonous to the human race and ought in theory to be removed as fast as they are formed.

It is often supposed that carbonic acid gas, being heavier than common air, must be precipitated to the floor as fast as it issues from the lungs. This is, however, provided against by the law of diffusion of gases. If it were not so the surface of the earth would soon become covered with an ocean of gas, in which no living being could exist, and every fire would be extinguished.

To prevent the accumulation of too large a quantity of this "choke damp," there is another provision of law by which plants require it as food. Vegetables and plants assimilate the carbon and liberate the oxygen, to be used over again in the respiration of animals. Thus in this way what is poison for one form of life becomes food for another.

There are numerous facts going to prove that carbonic acid gas diffuses itself in the atmosphere and is not precipitated to the floor or surface of the earth, in consequence of its being heavier than the air. De Saussure noted the presence of carbonic acid in the atmosphere of the summit of Mont Blanc, in the region of perpetual snow, and he states



GUY'S HOSPITAL VENTILATION.

explicitly that the proportion of this gas is greater on the tops of mountains than in the plains or valleys. This view has been confirmed by Gay Lussac, who made experiments upon air collected at great elevations in balloons.

Pure air is a mechanical mixture of twenty-one parts by volume of oxygen, and seventy-nine parts of nitrogen; it contains in addition four to six parts of carbonic acid in 10,000, also a quantity of the vapor of water, varying according to temperature. Finally, it holds in suspension a quantity of solid particles which play an important part in the phenomena of nature.

Every one has seen the atmospheric dust when a beam of light across a room makes it visible. These particles are so small that it is only by the aid of light that they are made visible. In order to collect and examine them it is necessary to draw a large volume of air through water or gun cotton. The cotton method has been successfully tried in hospitals, where a search was made for the germs of disease. After the gun cotton has caught these minute sporules it is dissolved in a mixture of alcohol and ether, and the sediment, on examination under a powerful microscope, will be found to be made up of a great variety of constituents, such as mineral and vegetable fibre, granules of starch, threads of cotton, atoms of charcoal, fragments of carbonate of lime, crystals of salt, and organic sporules. The most important o' these constituents in their sanitary effects, are the organic matters, which Pasteur and Tyndall have shown to be ferments.

In combating the doctrine of spontaneous generation, Professor Tyndall has had occasion to perform an extensive series of experiments in which the conditions of the atmosphere played an important part. Substances sealed up in tubes deprived of air, remained unaltered, but others of the same source when left in open vessels soon showed signs or putrefaction and fermentation. The germs in the air can also become the occasion of zymotic or ferment diseases, and are therefore proper objects of solicitude and study.

What we call pure air is therefore composed of oxygen, nitrogen, carbonic acid, vapor of water, fragments of vegetable and mineral substances, organic and miasmatic corpuscles. It will be seen by this that the best air we can obtain has a fair share of impurities. If the air of an occupied room loses one per cent. of its oxygen, respiration becomes difficult; the loss of four per cent. renders life nearly insupportable, and death arrives when the loss reaches five or six per cent.

The study of these facts has led mankind to try to obviate the inconveniences and dangers arising from vitiated air, and as a result we have the art of ventilation.

The ventilation of public and private buildings is altogether a modern invention. A century has scarcely elapsed since the question was first raised, although our knowledge has been greatly enriched by the experiments and researches of architects and men of science during these hundred years. It is a mortifying fact that the world has been slow to profit by what has been learned. It is true that attempts were made to ventilate mines from the earliest times; but it was not until Lavoisier made known the true nature of the air that any practical knowledge could be obtained of the subject.

In the celebrated work of Agricola, "*De re Metallica*, published at Basle in 1546, and devoted to the metallurgy of the sixteenth century, we find plans and drawings of the methods of ventilation in use at that early period. The apparatus consisted of enormous bellows manipulated by hand or driven by some kind of power. The bellows were attached to wooden tubes which penetrated to the bottom of the mine; and there were sometimes several pairs in operation at the same time. The fresh air was blown into the galleries, and the foul air made its exit up the mouths. In England, toward the close of the eighteenth century, mechanical means were employed to ventilate the Houses of Parliament, hospitals, and Newgate Prison.

Ventilation by chimneys was suggested in France by du Morceau and Gennetti. According to the system of the latter, outer air was introduced at the base of the building, and by means of a fire in a chimney under the roof a sufficient draught was produced to force it out at the top. In this way the foul air was drawn out of the building.

The most important contributions of the early part of the present century were made by Reid in England, and D'Arcet in France. The former introduced ventilating apparatus in the Houses of Parliament, Guy's Hospital, and many other public buildings, and wrote extensively on the subject. The latter gave to the principles of ventilation scientific precision, and contributed largely to make them known to the popular mind.

As soon as the necessity for fresh air was universally admitted, methods of supplying it were sought on every

side. The walls of rooms were pierced at the top and bottom, to afford access for pure air and exit for the foul. Holes were cut in the window-panes and revolving disks inserted. These measures, if not perfect, at least seemed to aid the natural ventilation, which commonly takes place through the chinks and doors of apartments, and thus lessens the danger arising from bad air.

There is a fact in connection with the study of ventilation in France which deserves to be mentioned here. It was not humanity that first suggested practical inventions in this line, but industry. It was not for the sick in hospitals that new devices were introduced, but for the silkworms in the spinning of cocoons. Observation showed the necessity of fresh air to the preservation of the worms, and it was carefully introduced; and after it was done, the same apparatus was pronounced to be equally useful for man.

A similar story is told by Mr. Henry A. Gouge, who was so successful in ventilating the stable of a well-known citizen, that he was permitted to apply his invention to a bank. First came the horses, then the men. The following is an account of his success: "The well-known New York Bank may be mentioned as an instance of imperfect ventilation, which came to my knowledge through the instrumentality of Judge Henry Hilton, of New York City, whose stable I had ventilated very much to his satisfaction. Owing to this circumstance, he was kind enough to give me a letter of introduction to the cashier of the above bank, suggesting that it would be well to employ me to ventilate the place."

Mr. Gouge was employed, and was eminently successful, thanks to his previous experiments on horses.

In France, after the success with silkworms, the first building to be ventilated was the House of Peers and Chamber of Deputies; then the prisons, the hospitals, the churches and the theatres received attention.

One of the most conspicuous writers on the subject in France is General Morin, a member of the Institute, and a Director at the Conservatoire des arts et Métiers. Probably no writer has done more than he to popularize the subject, and apply its principles to public and private edifices.

Another member of the French Institute, M. Combes, has contributed an important instrument to aid in the solution of some of the difficulties in the way of the study of currents of air. We owe to him the invention of the anemometer, an instrument designed to measure the quantity of air that can pass through any given aperture. Without this instrument we should be unable to adapt certain principles and obtain absolute control over the various forms of apparatus offered for competition. Combes's anemometer indicates the velocity of the wind by the number of revolutions imparted to a fan-wheel in a given time. It is a small windmill, to which is attached an index marking the number of revolutions per minute. The stronger the current the greater the number of revolutions made.

Two systems have been adopted to provoke ventilation. One by draught, and one by mechanism; each has its advocates, and both are no doubt applicable, according to circumstances. The method by a draught produced by a fire of some kind in a chimney, is more commonly employed, as there is less machinery about it, and it can be introduced, once for all, when the house is built. If the interior of an edifice communicates with a chimney of sufficient height in which can be built some kind of fire, the heat rarefies the air, which at once has a tendency to rise, and, by so doing, to produce a draught which carries the foul air of the building with it. In order to keep up the current, it is necessary to maintain a connection with the outer air, and to sustain the heat by replenishing the fire. The ventilation can be hastened or retarded by suitable valves, at pleasure. The simplest contrivance is to force the air to pass through the grate of a coke or coal fire. The strength of the draught must depend largely on the height of the chimney. Care should be taken to prevent the return of the foul gases into the building, and also not to contaminate the air of the neighborhood. Hence the chimneys ought to be made as high as they would be for an industrial establishment. The size of the flue must also be carefully studied. Too large a section requires a correspondingly large consumption of fuel, and too small a bore may admit the return of foul gases. A convenient velocity of draught in the chimney has been found to be at the rate of 3 feet to 3½ feet per second. The size of the chimney and the quantity of fuel can be computed from the height and the volume of air. The mathematical formulæ for such calculations are given by Peclet, in his celebrated work on Heat.

After a building has been put up, it is difficult to construct new chimneys and flues for the purposes of ventilation, and in such cases application can be had to gas as a source of heat, and to flues which can be put up within the building. The atmospheric ventilation of Mr. Gouge is one of the forms which appear to be admirably adapted to this purpose. The air within the ventilator is heated and set in motion by the combustion of gas or kerosene. A single Argand burner, consuming about a foot of gas to the hour, in connection with a proper system of inlet and outlet flues or air ducts, will produce the requisite movements of the air, and secure thorough ventilation in a building of moderate size. The air ducts are of variable size, and unless the larger and smaller ones have a proper and definite relation to each other, the current of the air will be imperfect. The upward force of an induced current of air has a strict relation to the capacities of the flues through which it is made to pass.

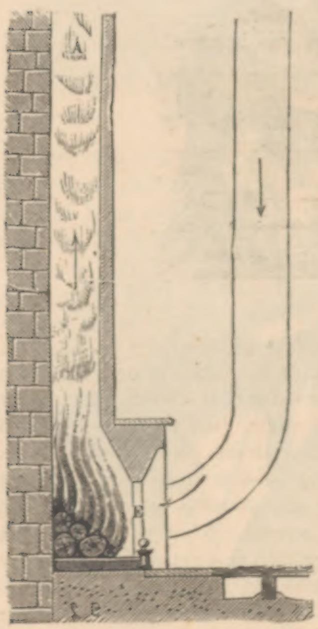
An English plan for ventilating rooms is mentioned with approval by the *Plumber and Sanitary Engineer.* It consists in admitting air from the outside, at the floor level, to pipes on the outside, which are about six feet high. The air thus admitted is passed over or through water, which can be renewed at intervals, through the pipe, or flushed when the water-receptacle needs cleansing. The air, passing

GENERAL MORIN.

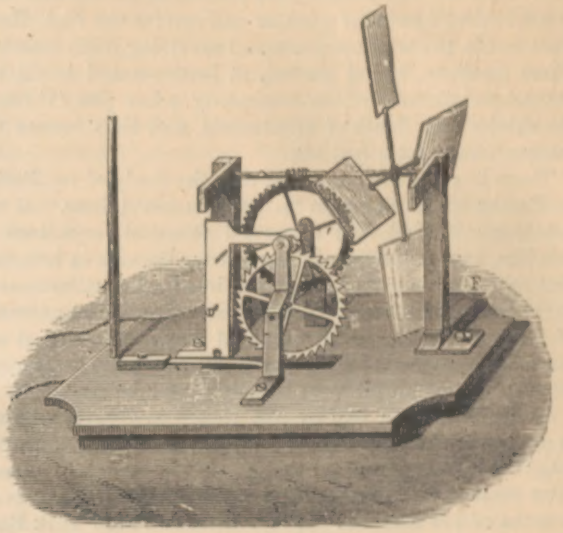
M. COMBES.

ing through the pipe, ascends in the room, mixes with the warm air near the ceiling, and eventually permeates the apartment. Something like this, so far as the admission of air is concerned, has been achieved in this country, by short pipes bent at right angles, to be set up in the openings of a window; and also, yet more cheaply, by the separation of the sashes in the middle, at their ordinary point of junction. But the difference between the outside and inside temperatures of dwelling-houses is much greater here than in England, and contrivances of the kind above described have generally a short-lived popularity in this country, because they soon cool apartments below the range of comfort in cold weather.

According to General Morin, chimneys may easily be made to serve as ventilators during the Summer, or on special occasions, by placing in them a tube furnished with several gas-burners. On the chimney of an ordinary apartment, having an earthenware flue eleven inches square and sixty-six feet high, the amount of air drawn up the chimney to each foot of gas burned will be greater the less gas is burned and the less the temperature of the flue. This mode of ventilation may be employed to advantage in drawing-rooms on reception-days, provided that registers be placed at convenient points for the introduction of moderately warm fresh air. During the Summer the system of ventilating



PRINCIPLE OF THE DRAFT OF CHIMNEYS.

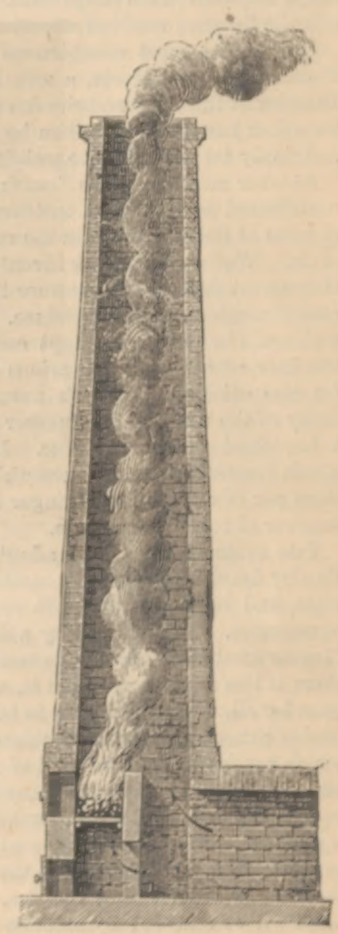


COMBES'S ANEMOMETER.

by means of gas-jets will also allow the room to be maintained at a lower temperature than that of the external air, by drawing in the air from clean cellars to replace that carried off.

The ventilating fireplace of Captain Galton has been much commended in England. His device differs little in external appearance from an ordinary grate, except that it has a high brick back, which forms the exterior boundary of a chamber, into which air passes directly from without, becomes moderately heated in a separate flue, and is injected thus into the room under the ceiling. A plenum of pressure is established within the room, whereby indraughts through doors and windows are avoided, and the air is continually renewed by passing away through the fireplace-chimney as usual. The fireplace-chimney is encircled by the air-flues, so that the heat of the ascending products of combustion is utilized throughout its whole length. Mr. William Siemens says of Captain Galton's invention that "the cheerfulness of an open fire, the comfort of a room filled with fresh but moderately warmed air, and great economy of fuel are here happily combined, with unquestionable efficiency and simplicity."

There are numerous examples of practical ventilation in this country, without the aid of mechanical contrivances. A plan for ventilating

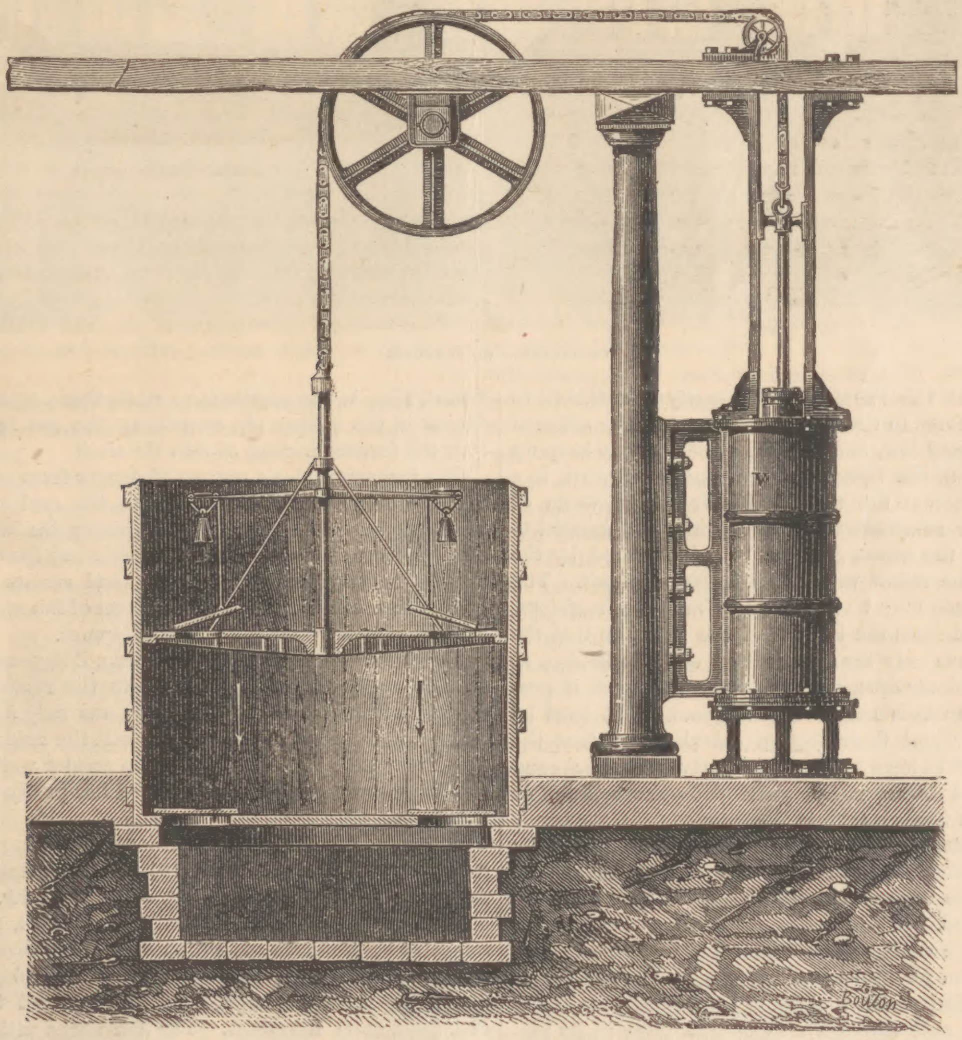


CHIMNEY VENTILATION.

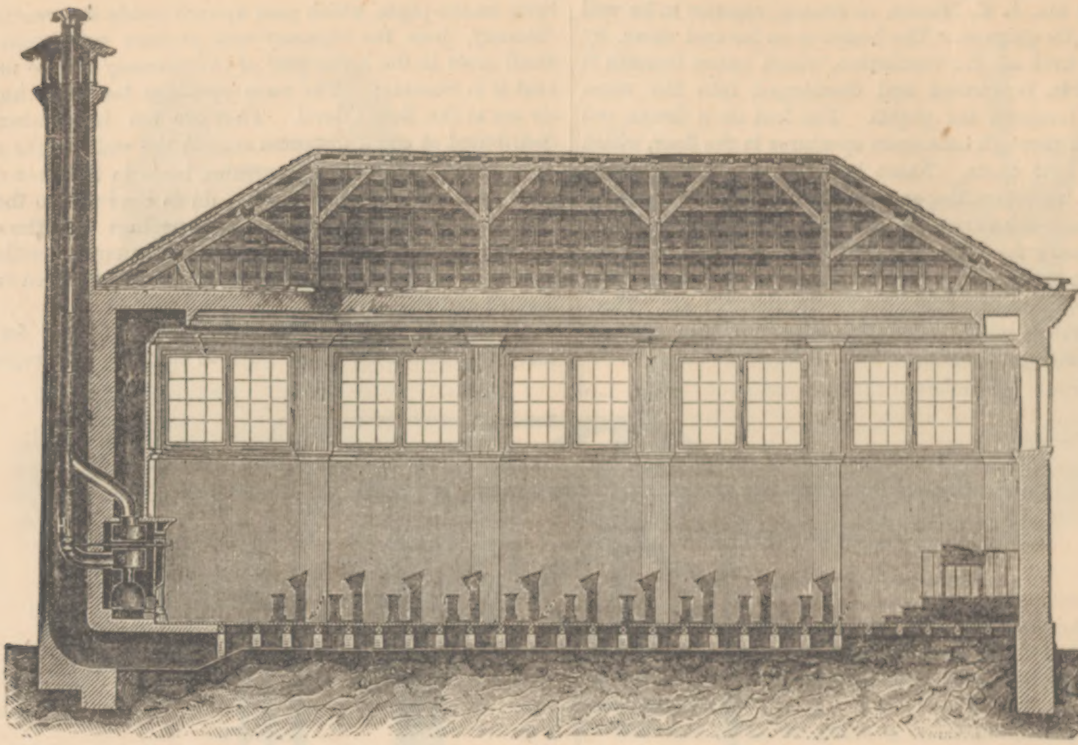
schools, by Mr. A. C. Martin, of Boston, appears to be well adapted to its purpose. The heater is an incased stove, by which the fresh air for ventilation, which enters beneath it from outside, is warmed and discharged into the room above the heads of the pupils. The foul air is drawn out of the room through numerous apertures in the floor, which open into four ducts. These lead to a ventilating chimney, kept warm by the smoke-pipe of the stove passing upward inside the chimney. A small stove may be placed in the chimney for Summer ventilation. Cold air inlets are provided at the ceiling to temper the air of the room when it is too warm, and to furnish additional fresh air. Horizontal deflectors under these openings direct the currents of cold air along the ceiling.

The second example, of a hospital ward, is from plans suggested by Doctor Folsom, for the Johns Hopkins Hospital. The ward is heated chiefly by two steam heaters in the basement, to which the outdoor air is supplied through two cold-air boxes which cross the basement from side to side, so that the air may always enter from the windward side—a provision which evinces the possibility of regulating the ventilation in windy weather. A mixing-valve permits the cold air to pass above the heater when it is necessary to cool the air which enters the wards through two registers, situated on each side of a large ventilating chimney in the centre of the ward. Two open stoves, built into the ventilating chimney, serve as auxiliary heaters, and their smoke-pipes, which pass upward inside the ventilating chimney, heat the chimney and produce ventilation. A small grate in the lower part of the chimney can be used to heat it in Summer. The main openings for removing foul air are at the floor's level. They are ten in number, and distributed at equal distances around the walls of the room. A downcast flue from each opening leads to the floor of the basement, beneath which all ten ducts converge to the bottom of the central chimney. Two openings into the chimney are provided near the ceiling for Summer ventilation, and there are *louvres* over the windows, all of which can be opened and closed at will.

According to General Morin, the plans adopted for primary schools should be designed to carry off and replace a volume of 400 to 500 cubic feet an hour for each child. The ventilating openings should be placed in or against the vertical walls of the two long sides of the room. It is only in case of great constructive difficulties that they may be confined to a single side. There should be as many of them as possible, and they should have a clear cross-sectional area that will give to the air carried off a velocity of more than twenty-eight inches a second. They should connect with descending flues leading into the cellar or under the floor of a collecting-pipe, which, in most cases, should be carried directly to the foot of the ventilating shaft. The latter should be placed for its whole length beside the smoke-pipe of the heater, the heat from which will assist



MACHINE FOR VENTILATING MINES.



VENTILATION OF SCHOOLS.

the draught. But this heat will not usually be sufficient to give proper activity to the draught, even when the external atmosphere is very low, and it will be necessary to keep up a little coal-fire at the bottom of the ventilating shaft, in a grate detached from the walls. The fresh air, warm or cold, should be admitted near the ceiling, and parallel to its surface. In the season for fires, the air supplied by the heater should be mixed with the external cold air. The proportion of each may be regulated by means of registers, easily controlled from the interior of the room, so that the mixture may have only the temperature of 85 to 95 deg. at most. The fresh-air openings should be arranged, if possible, along the whole length of the room, or at least be very numerous, and their section calculated so that the entering air should have a velocity of forty inches a second if it is directed horizontally, parallel to the ceiling, or twenty inches if it has a vertical direction.

Further illustrations of the ventilation of buildings by the system of draughts can be deferred until we have taken up the discussion of the mechanical contrivances more recently introduced.

The absolute necessity for a very active and certain system of ventilation for mines was the occasion of the invention of mechanical means to accomplish the purpose. The atmospheric air sent through a mine undergoes in its passage certain modifications which render it unable to keep the workings clear of gas. The respiration of men and animals gives birth to extremely deleterious gases, in which the oxygen disappears and gives place to carbonic acid, carbureted hydrogen, nitrogen and ammonia. For the safe working of such places, it is necessary that there should be a large and constant supply of fresh air sent from the surface, so as to permeate every part of the mine. To effect this, various systems have been tried, including the furnace, fans, steam-jets, screws, etc. The furnace was for a long time the chief method adopted. The amount of air produced by a well-constructed furnace varies from 4,000 to 8,000 cubic feet per minute for each foot in breadth of the bars. Still, the temperature of furnaces is very variable, and to some extent, also, is the ventilation; while there is considerable danger in the return air containing the gas being carried over the furnace instead of into the shaft.

The furnace is also a source of danger from other causes, as it has been known to set fire to the coal and produce great danger. On account of this danger, the furnaces have been replaced in many mines by machinery for accomplishing the ventilation. Pumps, fans and screws have been tried with varying success. Some form of fan appears, upon the whole, to have obtained the preference.

After the invention of the air-pump, it appeared very natural to apply the same principle to the removal of large volumes of foul air from mines. It was only a question of increasing the size of the pump to suit the work to be done. The larger the piston and valve, the greater were the obstacles to be overcome, and this method has pretty much given way to propeller screws and fans.

These are of different dimensions, according to circumstances. The fan is usually 13¼ feet in diameter, with 8 vanes, each 3 feet 6 inches wide, and 3 feet long. It is fixed on a horizontal shaft, 8 feet 7 inches in length, from centre to centre of the bearings, which are nine inches long by 4½ inches in diameter. The vanes are of tin plate iron and carried by forked wrought-iron arms secured to a centre disk fixed upon the shaft. The fan works within a casing consisting of two fixed sides of thin wrought plate, entirely open round the circumference, and connected together by stay rods; the sides are 3 inches clear from the edges of the vanes, and have a circular opening 6 feet diameter in the centre of each; from which rectangular wrought iron trunks are carried down for the entrance of the air; the bearings for the fan shaft being fixed in the outer sides of these trunks, which are strengthened for the purpose by vertical cast iron standards bolted to them, and resting upon the bottom foundation stone.

The fan is usually driven by the engine used in the hoisting. This form of apparatus has proved very effective in mines of more than a thousand feet in depth, and was at one time extensively used in England.

In New York City, the church in which Dr. John Hall preaches is ventilated in the most thorough manner by the same form of propeller screw that is used in the pneumatic dispatch. The fan or propeller draws pure air from a tower and drives it under the seats in the church through suitable canals. In each pew are registers within the control of the occupants. In Summer, the air is cooled and moistened by being brought into contact with water spray. In the Winter it is warmed before being forced into the church. The congregrations worshiping in this church are very large, but no complaints are ever heard of impure air or oppression of any kind. In this instance the blowing apparatus has proved entirely satisfactory.

The Capitol at Washington has an expensive and complicated apparatus designed to furnish pure air to the Senate Chamber and House of Representatives. A large quantity of air is drawn into chambers, where it is warmed by passing among stacks of pipes heated by steam-boilers, and forced into the halls of Congress through apertures in the floors and walls. The column of air thus introduced displaces an equal quantity of vitiated air, which escapes through openings in the ceilings and numerous doors leading into the halls and galleries. There are four fans employed for this purpose, operated by steam engines. The fan for the Senate Chamber is described as being 14 feet in diameter, and weighing over six thousand pounds, and is moved by an engine of 16 horse power. The fan for the House of Representatives is 16 feet in diameter and weighing nine thousand pounds, and requires a steam engine of 30 horse power.

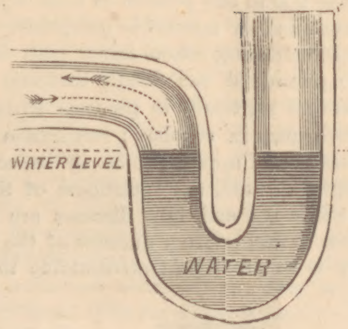
Notwithstanding this ponderous machinery, it seems to be impossible to prevent the air of the halls from becoming very foul and stifling.

In the Spring of 1876 there was so much illness among the members of Congress that committees were appointed to examine the ventilating apparatus. They found that the arrangements were such that the cold air sweeps down upon the floor and thus forces upon the members the foul atmosphere generated by the gas-burners and the occupants of the galleries. The fresh air supply is taken in through the basement into the cellar, and is then forced up by fans through iron pipes, which, it is said, are "coated by many years' accumulation of rust and particles of decaying animal and vegetable matter." From these the current goes through a series of horizontal ducts, and finally, at a temperature of 100 deg. or thereabout, is driven into the chamber through registers which, for years, have filled the office of spittoons!

It was further reported that the mouth of the sewer which drains the Capitol is submerged, so that from every sink there is an escape of sewer-gas into the building. Under such a condition of affairs, it was not to be wondered at that so many of the members were ill. Very energetic measures were adopted to remedy the evil, but there is still room for improvement.

HOW SEWER-GAS ESCAPES THROUGH OVERFLOW PIPE.

At the same time that Congress was aroused by the untoward condition of affairs at the Capitol, attention was directed to the bad ventilation of the public schools in New York City, and revelations of a startling character were made. A thorough inspection of the public schools situated in widely separated portions of the city showed that there was not one single building in which the occupants were not daily poisoned with foul air, through utter want of any adequate system of ventilation. I have myself seen 100 children packed into rooms capable of decently accommodating only one-half that number. They were compelled to remain there several hours; it was as much as I could endure to stop for a few minutes.



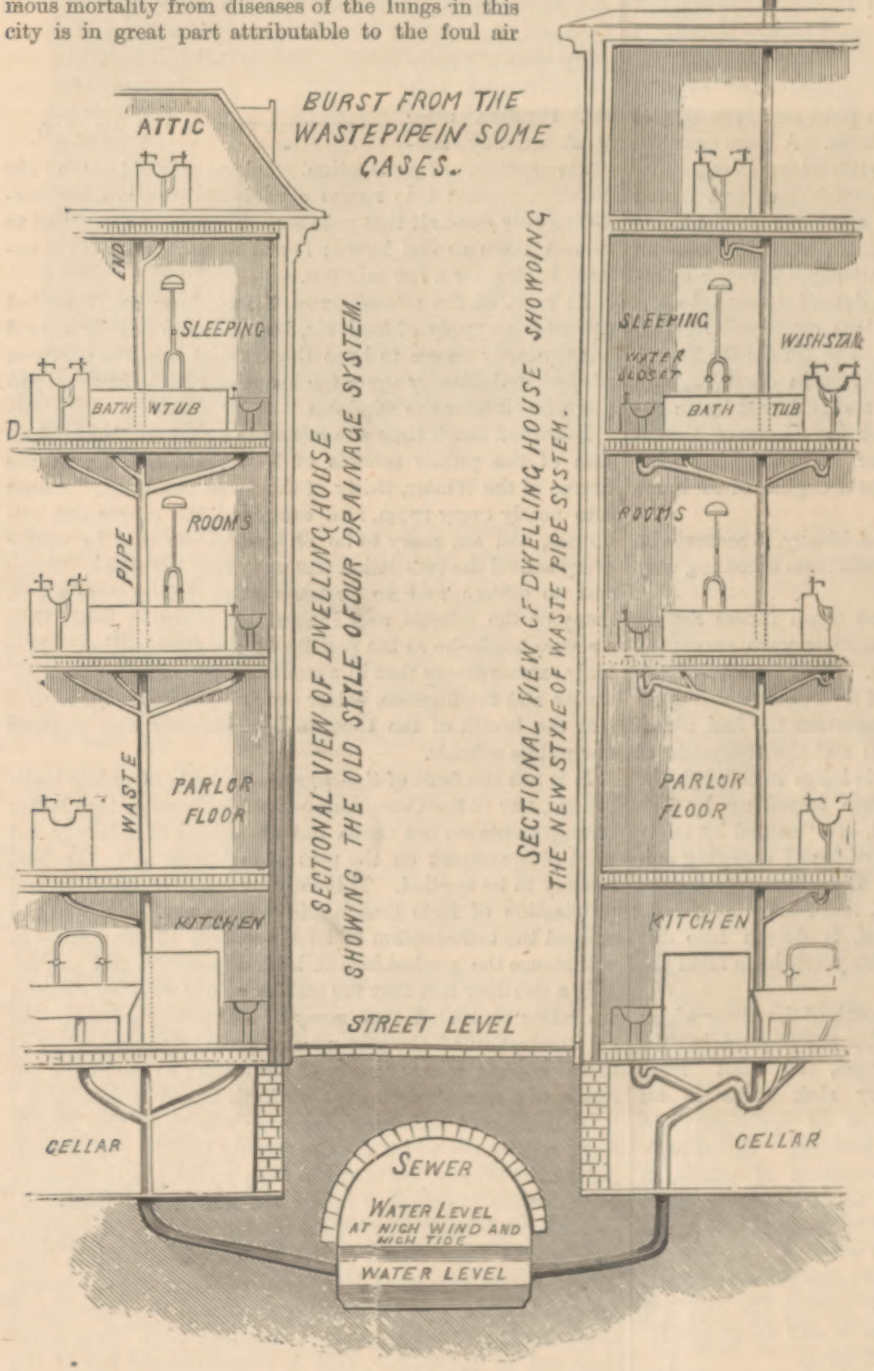
SECTIONAL VIEW OF FOUL AIR TRAP.

In most of the schoolhouses the windows are depended upon for a supply of fresh air, but on damp or cold days it is manifestly unsafe to have the draught from the windows precipitated directly upon the heads and backs of those pupils who sit near the windows.

I devoted much time one season to a systematic examination of the public schools of New York, visiting, in the course of the Winter, thirty of the finest buildings. I went into nearly every room, and examined the courts and outhouses, and am sorry to be obliged to say that in nearly every school the ventilation was unworthy the name. There was no system, and no pretense at providing pure air in many of the schools, and I invariably returned home with a severe headache as the penalty of my examination. It is truly extraordinary that in a community possessing so much wealth and intelligence, better provision is not made to protect the health of the thousands of children who frequent our public schools.

It is not the fault of the Superintendents of public institutions, nor of the Commissioners of Education that better arrangements are not made, but a false idea of economy and want of agreement on the part of architects as to the best remedy to be applied. It is only by constant iteration and publication of facts that public opinion can be brought to compel the introduction of such a system of ventilation as will insure the perfect health both of teachers and pupils. It is a startling fact that the stables of our wealthy citizens are better ventilated than many of our public schools. As an illustration of the general and most culpable neglect of these subjects, we may make the following extract from the report of a committee of the New York Board of Education: "Of the school buildings under the charge of this Board, there are not ten which are thoroughly healthy; in several, during the Winter, the cold has been so intense at times as to render the dismissal of the classes a matter of necessity, and it is no extraordinary sight to see teachers in the performance of their duties in school hours, dressed in furs. The obstacles presented by school buildings to ventilation, the great quantity of fresh air required, and the difficulty of obtaining it without unpleasant draughts, have been so serious and so formidable, that in comparatively few of the school buildings has any attempt been made to secure ventilation. The results of this general lack of ventilation are seen in the listlessness on the part of both teachers and scholars, and the dull following of routine, which are standing subjects of complaint, but which are only the inevitable consequences of breathing an atmosphere saturated with the noxious vapors exhaled from the lungs, bodies, and dress of

the masses of children congregated in a single building. From 200 to 500 pounds of fetid vapor are thrown off in the breath and by insensible perspiration, from every thousand children during school hours each day, in addition to some 200 pounds of the deadly carbonic acid gas. To breathe this foul air tends to produce irritability in teachers, and peevishness in scholars; respiration is often impeded, and a tight band appears to be drawn across the forehead. If long continued, the rottenness of the air is communicated to the lungs, and lung diseases are generated. The enormous mortality from diseases of the lungs in this city is in great part attributable to the foul air



breathed every day by the 100,000 children in the schools. The prevalence of scarlet fever, which for the past few years has been remarkably great, in the primary schools, may be attributed to the same cause in even greater degree."

The amount of air required for each person per minute is estimated by various authorities at from 4 to 10 cubic feet, and this requires specific and adequate ventilating arrangements. Undoubtedly doors, windows, and chance crevices afford a partial exchange of air; but it is this accidental ventilation which, by effecting the purpose in an imperfect degree, has prevented mankind from sooner discovering the want of something better.

Spontaneous ventilation through air flues from the ceiling to the roof, and from open windows and doors, may answer very well in

BEST STYLE OF WASTE PIPE.

Summer, except where many are crowded together, as in schools and asylums; but in cold weather, when the house is closed, fresh air must be introduced and foul air expelled by the application of force.

Some philosophers maintain that air is like a rope, it is much easier to pull it than it is to push it; others assert that it is better to pack it by propellers.

UMBRELLA STYLE OF WASTE PIPE.

As a rule, in buildings used for public occasions, of which complaints are so frequently heard, no pretense at effecting any ventilation is even attempted. The owners of the property knowingly shut up hundreds of people under circumstances that, if properly investigated, would be likely to subject them to criminal prosecution. The audience-hall is often situated in the middle of the building, and there is no possibility for fresh air to enter, excepting by circuitous passages of the hallways when a

door is accidentally opened. That such an utter disregard for the comfort and health of the community should be tolerated is a proof that the subject will bear frequent discussion until the proper remedy is applied. We can have the consolation, if it be a consolation, of knowing that they are no better off in other countries. Even the hall in Paris in which the meetings of the most celebrated body of men in the world, the French Institute, are held, is said to be the worst ventilated room in Europe. At a recent session the following scene occurred :

M. Bouley—We are plunged in a wholly irrespirable atmosphere ; it is intolerable. Instead of gas, I wish we could have our ancient candles restored to us.

M. le Verrier—I prefer illumination by gas, and have insisted upon some kind of ventilation ; but nothing has been done. We have General Morin with us, and in eight days all necessary apparatus could be installed, if it were so ordered.

General Morin—Eight days! Ten years have already elapsed since their installation was decided upon in principle, and yet nothing has been done.

M. le Verrier—The condition of things is shameful. There exists nowhere a room so badly ventilated as the hall of the Institute.

It is somewhat remarkable that no invention has been made for giving an alarm when the air becomes too foul for safe respiration. We have inventions to warn us of fire, and to alarm the household of the approach of a burglar; but of the insidious foe that enters everywhere, in every apartment of private houses, and riots unmolested in all public places, we are never warned in time to make good our escape. It would be well if we had some kind of signal to warn us of the danger, or some kind of automatic arrangements by which ventilating apparatus could be set in motion. The presence of fire-damp in mines is made known by the explosion of the small volume of air in the Davy safety-lamp. When this explosion takes place in the narrow canopy of the wire gauze, the miner knows that it is better to retreat until the danger is removed. Unfortunately the gases of close rooms are not of this explosive character ; if they were, we should not suffer so much from want of ventilation as we do now ; as no one would run the risk of being blown up for the pleasure of being suffocated. The gas which leaks through stoves and furnaces, and arises from imperfect combustion, known as carbonic oxide, can be absorbed in a way to betray its presence by the following ingenious invention: The apparatus consists of a small galvanic battery, with a bell attached, and an open test-tube containing liquid chloride of palladium. The chloride of palladium is extremely sensitive to the presence of carbonic oxide gas ; it absorbs the gas and precipitates metallic palladium ; the deposition of the metal in the bottom of the tube makes the connection of the galvanic current and at once rings the bell, which will not stop its clatter until the current is broken. The invention is found to work admirably for carbonic oxide gas, and the next thing is to devise a plan for disclosing the presence of carbonic acid gas. It is possible that this could be done by putting in a carefully counterpoised balance some caustic baryta or lime, which, by the absorption of the carbonic acid of the air, would sink, and cause the current to be closed in a battery and the bell to be rung. The same contrivance could be made to open and close a shutter, just as the draught of a stove is regulated by the rise of mercury in a thermometer connected with a battery. It would be a novel experience on any public occasion, to have the proceedings interrupted by the ringing of alarm bells until equilibrium was restored by proper ventilation. We should all take kindly to the interruption, and be thankful for a breath of pure air. No doubt some such inventions will be introduced as soon as a knowledge of their existence becomes known and there is a universal demand for them.

THE BLACK HOLE OF CALCUTTA.

The Metropolitan Board of Health of the City of New York has been fully alive to the importance of securing proper ventilation in all buildings subject to their visitation. Whatever is dangerous to human life and detrimental to health, properly comes under their cognizance, and under this category may be safely included the improper ventilation of tenement-houses and public buildings of all kinds. The enforcement of the "Tenement-house Act" by the Board of Health has resulted in a considerable improvement in the condition of the tenement-houses of New York. Additional

means of ventilation have been insisted upon, and the attempt has been made, with some success, to educate the people in the densely populated parts of the city as to the necessity of cleanliness and obedience to the sanitary regulations of the Board.

The 24,000 tenement-houses of the city require constant supervision and frequent inspection. Rooms will be found overcrowded; windows and doors, and apertures for ventilation will often be purposely closed; refuse matter will be thrown into the sinks, and filth generally will accumulate in the halls, cellars and yards. Through the instrumentality of the Board, ventilating shafts have been introduced into many large tenement houses, and the average number of deaths has been largely diminished. Unfortunately, the sanitary inspectors do not feel at liberty to examine the dwellings of the rich, and they really suffer more, in proportion to the number of occupants of a single house, than the poor.

Much has been said and written about the defective plumbing and drainage of our city houses, but still more can be added before all the perils of the situation can be disclosed. What are called "modern conveniences" are in many instances inventions for increasing the bills of mortality. There is often a curious inconsistency about them. While they provide for ventilation, in some instances the very apparatus designed to secure pure air in the dwelling actually draws the foul air into it, through pipes connecting with the sewer. The traps are exhausted or syphoned out, and the foul air has free course into the living apartments, thus producing the many cases of zymotic disease now so common among the wealthy. To prevent such disastrous consequences, all the traps of the house should be ventilated by separate pipes, thus preventing them from becoming exhausted by any accidental suction from within.

Astonishing illustrations of the disregard of the laws of health on the part of citizens who can scarcely plead ignorance as an excuse, are afforded in the crowding together of a great number of persons at a fashionable reception in the splendid mansions of the metropolis. There is often such a jam that to accomplish the feat of ascending to the cloak-room, paying your compliments to the host and struggling your way out of the house is as much as a vigorous person can accomplish in three hours. And yet, here you have a dense phalanx of persons upon whose education no expense has been spared. Their dresses are imported for the occasion; the refreshments are delicious—what it has required months, and, in some cases, even years of unremitting attention to produce; the splendid furniture offers every comfort that ingenuity can devise; and yet, within this painted sepulchre, what is the analysis of the air we breathe? Has any one thought of bringing with him the hogshead of air per hour necessary for his respiration? and if not, in what manner has the host performed this duty? The closed ceilings answer the question, and one only has to glance at them to perceive that the crush of people present are, like those in the Black Hole of Calcutta, conglomerated together in a hermetically sealed box of vitiated air. How long must it be before such an exhibition will be an indictable offense, and its repetition be prohibited by law?

There is some prospect that the recent successful liquefaction of gases, and the consequent unusual attention now bestowed on this branch of science, may lead to important discoveries in the practical manipulation of æriform bodies, which will relieve mankind of one of its worst foes, namely, vitiated air. Such a result would certainly be hailed with satisfaction by the whole world, and it is a consummation devoutly to be wished.

We cannot do better than to close our article with a quotation from an anonymous poet, who, in quaint but forcible language, enforces the necessity of providing for ventilation:

AN APPEAL FOR ARE TO THE SEXTANT OF THE OLD BRICK MEETINHOUSE.

BY A GASPER.

Oh, Sextant of the meetinhouse which sweeps
And dusts, or is supposed too! and makes fires,
And lites the gas, and sometimes leaves a screw loose,
In which case it smells orful—worse than lampile;
And rings the bel and toles it when men dyes
To the grief of survivin pardners, and sweeps pathes,
And for the servaces gets $100 pur annum,
Which them that thinks it deer, let em try it;
Giting up befoar star-lite in all weathers and
Kindlin fires when the wether is as cold
As Zero, and like as not green wood for kindlers
i wouldn't be hired to do it for no some—
But o sextant! there are one kermoddity
Wich's more than gold, which doan't cost nuthin,
Worth more than anything exsep the Sole of Mann
i mene pewer Are, sextant, i mene pewer Are!
O it is plenty out o dores, so plenty it doant no
What on airth to do with itself, but flys about
Scatterin leavs and blowin orf men's hatts;
in short its "just as free as are" out dores.
But o sextant, in our church its scarce as piety,
scarce as bank bills when agints beg for mischuns,
which some say is purty often (taint nothin to me
Wat i give aint nothin to nobody); but o sextant
u shet 500 men, wimmen and children,
Speshally the latter up in a tite place,
Some has bad breths, none aint 2 swete.
Some is fevery, some is scrofilus, some has bad teath,
And some haint none, and some aint over clean;
But every one on em breaths in & out & in,
Say 50 times a minit, or 1 million and a half breths an our
How long will a church-ful of are last at that rate,
i ask you, say 15 minits, and then what's to be did?
Why then they must breethe it all over agin,
And then agin, and so on, till each has took it down
At least 10 times, and let it up agin, and wats more
The same individible doant have the priviledge
Of breethen his own are, and no ones else;
Each one must take whatever comes to him.
O sextant, doant you know our lungs is bellusses,
To blo the fier of life and keep it from
goin out; and how can bellusses blo without wind,
And aint wind *are?* i put it to your conshens.
Are is the same to us as milk to babies,
Or water is to fish, or pendlums to clox,
Or roots and airbs are to an injun Doctor,
Or little pills to an omepath,
Or boys to gurls. Are is for us to breethe,
Wat signifies who preaches if i cant breethe?
Whats Porl? Whats Pollus? to sinners who are ded.
Ded for want of breth? why sextant when we dye
Its only coz we cant breethe no more—thats all.
And now o sextant, let me beg of you
2 let a little are in our church.
(Pewer are is certain proper for the pews.)
And do it week days, and Sundays 2
It aint much trouble—only make a hole
And the are will cum in of itself
(it loves to cum in whare it can get warm)
And o how it will rouse the peeple up,
And sperret up the preecher, and stop garps,
And yauns and figgits as effectooal
As wind on the dry Boans the Profit tells of.

RECENT PROGRESS IN SCIENCE.

The Chemical Preservation of Wood.—In Europe the use of preserved timber is the rule; in the United States it is the rare exception. The apparently inexhaustible supply of timber in America led to great carelessness in its use, and the present generation have inherited what bids fair to become a bankrupt estate, unless the loss can be retrieved by the employment of methods of chemical preservation. No fewer than 173 processes have been patented or described in scientific books since the year 1700, a vast majority of